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Aberdeen Proving Ground

OWPG-1327--24 Oct 51

MARYLAND

PLATE PENETRATION COMPARISON TEST OF THE
STANDARD 90MM, AP, T33E7 SHOT AND
100 ALTERNATE DESIGNS (U)

THIS DOCUMENT CONSISTS OF 19 PAGES

COPY 8 OF 9 COPIES,
DEVELOPMENT AND PROOF SERVICES

Report

OCO Project No.

PA1-21

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1327--24 ABERDEEN PROVING GROUND, MD-415

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DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

RNDempsey and JGMelson/tsp
October 1957

PLATE PENETRATION COMPARISON TEST OF THE
STANDARD 90MM, AP, T33E7 SHOT AND
TWO ALTERNATE DESIGNS (U)

DATE OF FIRING: 30 - 31 JULY, AND 1 AUGUST 1957

ABSTRACT

OBJECTIVE

To determine the penetration abilities of two designs newly submitted as compared with the standard design 90mm, AP, T33E7 shot.

SUMMARY

Plate ballistic limits were determined on 3-inch homogeneous armor plate at 60° obliquity for the standard shot and the two alternate designs. The PEL obtained were:

- a. Standard 90mm AP T33E7 (with windshield) - 2813 fps.
- b. "Sleeve" design 90mm, AP, T33E7, (without windshield) - 2785 fps.
- c. "Two-piece" design 90mm, AP, T33E7 (without windshield) no complete penetrations were obtained within the gun rated maximum pressure of 47,000 psi.

CONCLUSION

The "sleeve" design appears capable of penetrating more armor at the same striking velocity than either the standard or "two-piece" design shot.

RECOMMENDATION

The 90mm T33E7 "sleeve" design with windshield should be fired and the results compared with the standard design from the same heat of steel to determine which has the higher penetrating ability.

58AA



RECORDING DATA CANNOT BE PRESENTED

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I. INTRODUCTION

The method now used to attach windshields to AP shot is the Cycleweld C-14. Occasional reports have been received of windshield separation during flight. Many of these failures can be attributed to improper obturation and/or improper cyclewelding techniques. To alleviate the problem of improper cyclewelding, an impact fixture was designed and incorporated in the shot manufacture. Even though the impact fixture insures a minimum bond strength, gas "blow-by" can cause windshield failure. Therefore, by eliminating the joint between windshield and shot body by incorporating it into a sleeve to fit around the shot body, both problems (gas "blow-by and cyclewelding") are eliminated.

II. DESCRIPTION OF MATERIAL

A. Twenty standard 90mm T33E7 reference rounds (Drawing No. 75-2-545).

B. Two-piece Body:

This design incorporates the 98V65 hardened triple alloy steel ogive tip screwed into a 1100 series steel body (Drawing No. F77760, Revision A).

C. Sleeve Design:

In this design (Drawing No. FDL9596 Revision A), the diameter of the standard 90mm T33E7 AP shot has been reduced by approximately .060. A cylinder or sleeve of 1100 series steel is forced over this surface and finish-machined to the standard shot configuration.

(Note) Paragraph C was copied from TPR #PA-MIC-8-1, Item 6a. However, this does not coincide with drawing number FDL9596 and 75-2-545, which would require a diametric decrease of $3.520 - 3.257 = .263$ instead of .060.

III. DETAILS OF TEST

A. PROCEDURE

1. The essential number of rounds were fired at 3-inch homogeneous armor plate at 60° obliquity (BBN-321; Charpy-ambient temperature 51 foot-pounds, -40°F 42 foot-pounds) to determine a plate ballistic limit for each of the three designs.

2. Velocities were measured by firing through two solenoid coils placed in front of the gun and recording projectile transit time by counter-chronograph. From this measured velocity muzzle velocities were calculated. Knowledge of the distance from the second coil to the plate enabled striking velocities to be calculated.

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3. Chamber pressures were measured on all rounds by placing two each medium caliber M3 gages in the base of the case.

4. All round-by-round data and other pertinent information is available in Appendix B (Firing Record No. P-62806).

B. RESULTS

1. A plate ballistic limit of 2813 fps was obtained by the firing of the standard 90mm, AP, shot (Test round numbers 7, 9, 10, 11, 12, and 13).

2. A plate ballistic limit of 2785 fps was obtained by the firing of the modified 90mm AP T33E7, reduced diameter body with sleeve (Dag. No. FD 19595, Revision A). (Test round numbers 4, 5, 6, 8, 9 and 10.)

3. No plate ballistic limit was obtained by the firing of the modified 90mm, AP, T33E7 shot of the two-piece body design (Dag. No. FF 7760, Revision A). No complete penetrations were obtained when the design was fired at charges producing a striking velocity of 2981 fps (3017 fps muzzle velocity), and a chamber pressure of 49500 psi (47000 psi is gun-rated maximum pressure).

4. All striking impressions on the plate were of the same essential shape, indicating that the break-up and rolling of the shot of all designs was essentially the same.

IV. CONCLUSIONS

A. The penetration capabilities of the two-piece design for Shot, AP, T33E7 does not favorably compare with the standard and sleeve designs when firing against 3-inch homogeneous armor at 60° obliquity.

B. The penetration capabilities are apparently greater for the sleeve design than for the standard design when firing against armor plate at 60° obliquity.

V. RECOMMENDATIONS

It is recommended that:

A. The two-piece design be considered unsatisfactory based on penetration limits obtained with the standard and sleeve design shots.

B. The sleeve design and the standard design be compared by means of a plate penetration test. Both designs should be made from the same heat of steel and the test conditions include high, intermediate and low obliquity targets.

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1. At high and low obliquities.
2. Of rounds of the same base lot number.
3. Of rounds all with windshields

C. Consideration be given to the design and comparative testing of 90mm T33E7 shot with penetrators of decreasing diameters.

SUBMITTED:

Robert N. Dempsey

ROBERT N. DEMPSEY
Project Engineer

James G. Nelson

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APPROVED:

H. A. Noble

H. A. NOBLE
Assistant to the Deputy Director
for Engineering Testing
Development and Proof Services

REFERENCES

1. Test Program Request #FA-MIC-8-1, Frankford Arsenal, Philadelphia 37, Pennsylvania.

OBSERVERS

Mr. M. A. Pilla
Frankford Arsenal, Philadelphia 37, Pennsylvania

APPENDICES

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APPENDIX A

ORDNANCE CORPS
FRANKFORD ARSENAL
PHILADELPHIA 37
PENNSYLVANIA

112-1112/3177

IN REPLY
REFER TO

ORDEAL-AR

TA 400-112/30 (p. 1)

30 January 1957

SUBJECT: Transmittal of Test Program Request FFA-IC-8-1

TO: Commanding General
Aberdeen Proving Ground
Maryland

ATTENTION: DAPS, Mr. G. Youmans

FA-1-2/

1. Forwarded for your information and retention is Frankford Arsenal's Test Program Request FFA-IC-8-1 which outlines a program to determine the capabilities of two (2) designs of the 90mm T33E7 AP shot against plate.

2. Part of the material is on hand at your Proving Ground with the exception of the modified 90mm T33E7 AP shot. It is anticipated that the material for test will arrive at your Proving Ground during the last week of February 1957.

3. It is requested that this Arsenal be notified in advance of the firing so that representatives may witness the test.

FOR THE COMMANDER:

4 Incls (in dup)

1. TPR FFA-IC-8-1-1 (quadrant & P)
2. Dwg 75-2-545 Rev 1
3. Dwg FF 7760 Rev A
4. Dwg FD 19596 Rev A

L. G. JULL
Lt Col, Ord
Assistant

cc: OAC, ORDELY-ARAR, Mr. L. Frank w/incls
Pic Ars, Mr. D. Clark w/incls

Test Program Request F7A-110-6-1
Frankford Arsenal, Phila. 37, Pa.

WFPilla/np/3177
30 January 1957

1. Material for Test:

a. Ammunition:

- (1) Twenty (20) standard 90mm T33E7 - To be used as reference rounds.
- (2) Twenty (20) modified 90mm T33E7 - (Two-piece body).
- (3) Twenty (20) modified 90mm T33E7 - (Reduced diameter body with sleeve)

b. Applicable Drawings for use in testing:

- (1) 75-2-545 Revision 1
- (2) FF 7760, Revision A
- (3) FD 19596, Revision A

2. Project Authority:

- a. OAC Work Directive 50304231-19-08602 dated 11 April 1955.

3. Arsenal Expenditure Order No.: 64922-01

4. Object of Development or Experiment:

To develop a mechanical method of attachment together with the necessary fixtures, if any, for insuring windshield security of the 90mm AP shot.

5. History Sketch:

The present method of attaching windshields to AP shot employs the use of Cycleweld C-14. Ever since Cycleweld was first used, occasional reports from the field have been received of windshield separation occurring in flight. Investigations by this Arsenal's personnel have revealed that many of these failures can be attributed to gas leakage into the windshield because of improper obturation and improper cyclewelding. In order to minimize the problem of improper cyclewelding, an impact fixture has been devised, and incorporated into shot manufacture. However, even though the impact fixture insures a minimum bond strength, propellant gas "blow-by" can still cause windshield failure. In order to minimize or eliminate the problem of improper obturation, elimination of the joint between windshield and shot body will be tried. Therefore, to provide a windshield which will not employ cycleweld, hence, one on which improper obturation will have no effect, a steel drawn windshield will be investigated as a possible substitute for the present type. In conjunction with this program, a second phase will be included, concerning conservation of triple alloy steels.

Test Program Request WFA-MED-8-1
Frankford Arsenal, Phila. 37, Pa.

6. Description in Detail of Improvements Made Since Last Proving Ground Test:

To determine the advantage of using a drawn steel windshield before punch and dies are prepared and the conservation portion, two (2) designs have been prepared. Although these designs were test fired under Test Program Request WFA-ED-419, the resulting data, although enlightening, was incomplete because of sample size.

a. Sleeve Design:

In this design, Drawing PD 19596 Revision 1, the diameter of the standard 90mm T32E7 AP shot has been reduced by a depth of approximately .060. A cylinder or sleeve of 1100 series steel is forced over this surface and finished machined to the standard shot configuration.

b. Two-Piece Body:

In this design, Drawing FF 7760 Revision 1, the ogive tip is made of triple alloy steel while the body utilizes 1100 series steel.

7. Local Tests:

None

8. Object of Test:

To determine the penetration abilities of the two (2) designs submitted as compared to the standard design.

9. Precautions in Handling and Testing:

Normal safety precautions should be exercised in handling AP shot.

10. Recommended Test Program:

a. All rounds are to be fired against four (4) inches of homogeneous armor plate set at an angle of 65° obliquity.

3 @ 60°

b. Establish a FBL for the reference and test rounds.

c. Record pressures, velocities (muzzle and striking).

d. Take photographs at the plate to reveal the nature of the shot break-up.

e. Record any other data considered pertinent by the Proof Director.

Test Program Request #74-110-8-1
Frankford Arsenal, Phila. 37, Pa.

11. Coordination:

Ordinance Ammunition Command, 6701Y-0312
Picatinny Arsenal
Aberdeen Proving Ground
Frankford Arsenal

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APPENDIX B

**DEVELOPMENT AND PROOF SERVICES
ARMEDEN PROVING GROUND, MARYLAND
FIRING RECORD**

OBJECT OF TEST: To Determine the
Penetrating Abilities
of Two Designs Newly
Submitted as Compared
with the Standard
Design 90mm, T33E7 AP
Shot (U)

DATE OF TEST: 30 July 1957
FIRING RECORD NO. P-62806
SHEET 1 **OF** 4
AUTHORITY: OAC Work Directive
50304231-19-08602
Dated 11 April 1955
WORK ORDER NO. 331-719-01

DEVELOPMENT: OROBA-MIR
PROJECT NO.: PA-1-21
TEST PROGRAM REQUEST NO.: PA-MIC-8-1

top

MATERIEL

GUN : 90mm TL19E1, No. 6129.
TUBE : 90mm TL19E1, No. 54959.
MOUNT : Rock Island Proof Mount No. 5.
RECOIL: Mechanism, 155mm, M21, No. 128.

AMMUNITION

PROJECTILE: 90mm, AP-T, T33E7, Lot No. RTQ 6-3.
90mm, AP-T, T33E7, Lot No. PA-B-3900.
90mm, AP-T, T33E7, Lot No. PA-F-3901.
PROPELLANT: MP-M6, Lot No. SJM-B-62827-53, .0545 web.
PRIMER : M-58, Percussion, 300 gr.
CASE : Cartridge, T-24E1, 90mm.

INSTRUMENTATION

Velocity Measurement-

Velocities were measured by firing through two solenoid coils a known distance apart, wired to a counter-chronograph. Knowing the distance from the muzzle to the first coil, and from the second coil to the plate, allows the muzzle and striking velocities to be given as relative velocities.

Pressure Measurement-

Chamber pressures were measured by means of medium caliber, M-3 pressure gages, (2 per round), Copper Lot 7C-55.

ARMOR PLATE DATA

Armor, Rolled Homogeneous, 3" x 72" x 72" No. 0100637-A
Average MIN: 321 Charpy (-40°F) 43 and 41 (V 1b)
Charpy (ambient) 51 and 52 (V 1b)

Composition (%): C Mn P S Si Mo B Ti
.27 1.76 .015 .017 .10 .59 .0005 .022

ROUND-BY-ROUND DATA

Standard 30mm T33K7 AP

DATE: 30 July 1957

TEST NO.	NO.	VELOCITY FPS	STRIKING VELOCITY FPS	PROPELLANT WEIGHT lb	CHAMBER PRESSURE psi/100	PKM WT lb	COMMENTS	ENTRANCE HOLE DIAM inches	EXIT HOLE DIAM inches	CRACK LENGTH inches
1	2600	2591	0	7	300	26.10	1/2" bulge on back of plate.	6-7/8x5	--	--
2	2609	2692	4	7	396	26.10	do.	6-1/8x4-1/8	--	--
3	2609	2672	7	7	392	26.00	5/8" bulge on back of plate.	7-1/2x5-3/8	--	1
4	2732	2713	2	7	412	26.09	1" bulge on back of plate.	7x4-1/2	--	1-1/2
5	2701	2764	13	7	429	26.13	1-1/2" bulge on back of plate.	8x5-1/2	--	15" circular 4-1/4" straight
6	2703	2746	13	7	402	26.14	1/2" bulge on back of plate.	7x4-1/4	--	--
7	2027	2010	0	8	435	26.10	5/8" bulge on back of plate.	7x4-1/4	--	--
8	2705	2769	15	7	411	26.12	3/4" bulge on back of plate.	6x4-1/2	--	--
9	2010	2001	0	8	442	26.09	do.	6-1/2x4-1/2	--	--
10	2057	2040	3	8	440	26.11	Complete	7-1/4x4-3/4	3-1/4x2	--
11	2040	2023	2	8	443	26.12	"	7-1/4x4-5/8	3-1/4x2	--
12	2029	2012	14	8	443	26.00	"	7-1/2x4	6-1/2x7-1/2	--
13	2010	2793	0	8	425	26.10	1/2" bulge on back of plate.	7-1/2x3-3/4	--	--

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Sleeve Design 90mm T33E7 AP

TIME NO.	MUZZLE VELOCITY fps	SHOOTING VELOCITY fps	PROPELLANT WEIGHT		CHAMBER PRESSURE psi/100	PROJ WT lb	COMMENTS		ENTRANCE HOLE DIAM inches	EXIT HOLE DIAM inches	CRACK LENGTH inches
			lb	oz							
1	2871	2835	8	4	440	23.53	1-1/4" bulge on back of plate.	8x4-1/2	--	4 1/2" circular	
2	2876	2842	8	4	442	23.52	5" hinge	8x4-1/4	11x11	--	
3	2872	2838	3	3	443	23.52	2" hinge	7-1/2x4-1/4	6-1/4x4	--	
4	2846	2814	8	2	428	23.50	-	8x4-1/2	5x4-1/2	--	
5	2836	2802	8	0	412	23.50	1-1/2" bulge on back of plate.	8-1/2x4	--	3	
6	2820	2706	8	0	418	23.50	6" hinge	8x4	6x4	--	
7	2813	2783	7	15	425	23.53	1/2" bulge	8x3-3/4	--	--	
8	2814	2780	7	15	422	23.54	7-7/8"x7" spall on back of plate.	7x4-1/2	3-3/4x3-3/4	--	
9	2800	2766	7	14	416	23.53	1/2" bulge on back of plate.	7x3-1/4	--	--	
10	2793	2759	7	14	420	23.51	1/2" bulge on back of plate.	7x3-3/4	--	--	
DATE: 1 August 1957											
1	2873	2830	8	4	431	23.60	1/2" bulge on back of plate.	6x4-1/2	--	--	
2	2833	2800	8	8	455	23.56	3/4" bulge on back of plate	6-3/4x4	--	--	
3	2897	2862	8	12	491	23.64	1" bulge on back of plate.	7x4	--	--	
4	2817	2831	8	14	495	23.63	1/2" bulge on back of plate.	6-1/2x4-3/4	--	--	

NOTE: The sleeve design shot weighed less than the standard design shot yet produced a lower PHL for this firing.
The sleeve design shot produced a PHL at an energy level 946,000 ft.-lbs/in.² (cross-sectional area of penetrator) lower than did the standard design shot.

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FIRING RECORD NO. P-62606
SECRET 1 OF 1

This firing record forms a part of report TFR No. FA-MIC-8-1.

H. A. Lechow

E. A. LECHOW
Chief, Artillery Division

H. B. Anderson

E. B. ANDERSON
Chief, Artillery
Ammunition Branch

Robert Y. Dempsey

Pvt. James G. Nelson

ROBERT Y. DEMPSEY
PVT. JAMES G. NELSON
Project Engineers

APPENDIX C





APPENDIX D

Composition Data of Plate, Rolled
Homogeneous, 3" x 72" x 72" (No. 0186637-A).

Manufacturer: U. S. Steel

Specification No. MIL-A-12560

Type Armor: Rolled Homc

Size 3 x 72 x 72

Chemical Composition

C	Mn	P	S	Si	Mo	B	Ni
.27	1.76	.015	.017	.18	.59	.0005	.022

Heat No. 71M 638

Plate No. 0186637-A

Thick. 3"

Actual HEN: 321

Charpy(Temp. ft./lbs) Ambient 51, 52

-40° 43, 41

Location Lt. Armor

APPENDIX E

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